PERSISTENT ORGANIC POLLUTANTS (POPS) IN HUMAN MILK FROM SAHARAWI WOMEN LIVING IN REFUGEE CAMPS IN SAHARA, SOUTH-WEST ALGERIA

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Introduction

Since the occupation of Western Sahara by Morocco in 1975, thousands of people from Western Sahara, called Saharawi, have lived in different refugee camps in the Sahara desert, near to Tindouf, South-West (SW) Algeria[1]. Living conditions are harsh with temperatures above 50^0 C, frequent sand storms but also floods. The camps are administered by the Saharawi exile government Polisario, but under the protection of the United Nations (UN). The majority of the refugees suffer of chronic malnutrition and anaemia[2,3]. The population is highly dependent on imported food stuffs, provided by UN and international NGOs. Typical food items that are distributed in the Saharawi refugee camps are cereals, lentils, oil, sugar, blended fortified cereal foods and canned fish[3,4]. Milk and meat from goat and camels are the only local produced food items of importance. Food is considered to be the main route of exposure to persistent organic pollutants (POPs) for humans[5]. Animals are exposed to POPs mainly through feed, but may also be exposed by treatment with insecticides. Because there is little or no natural vegetation in the refugee camps goats are often fed with soaked cardboard. It has not been investigated earlier how this may influence the goats and human contamination pattern. Due to geological conditions, the drinking water in the area is highly contaminated with iodine, causing goitre[6,7]. Based on the special living conditions of the refugees and their food supply from other regions, the main goal of this study was to investigate occurrence and levels of in human milk from Saharawi women and in milk from goat and camel.

Materials and methods

During 2007-2010, samples of human milk, goat milk and camel milk were collected in four Saharawi refugee camps: El Aiun, Smara, Awserd and Dakhla, close to the border of West Sahara (27°40′15″N 08°08′50″W) (Figure 1). The samples were initially used to investigate the population's exposure to iodine[8]. A smaller number of the samples were selected for measuring contents of POPs (31 human, 4 goat and 15 camel milk) (Table 1). The selection criteria were: the Saharawi women should be breastfeeding their first (primipara) or second child (multipara), they should be in good health, and milk from either goat or camel should be included in their diet. The selection criteria for the animals were that they were related to the households of the selected women. Questionnaires with information on personal characteristics, diet, life style and others were filled out. All women gave their consensus for the study and permission was given by the Saharawi Health Authorities. Furthermore, the study was proofed by the Norwegian regional committee for medical and health research ethics.

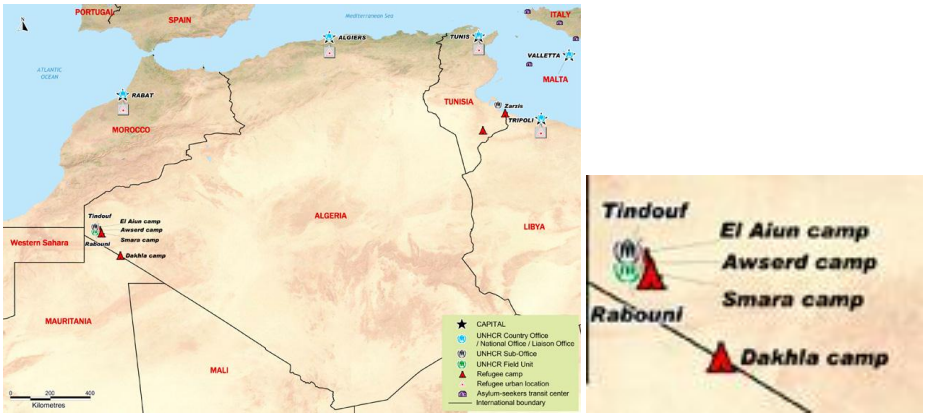

Figure 1. Map of Algeria showing the refugee camps El Aiun, Smara, Awserd and Dakhla (UNHCR, 2013).

The milk samples were sent frozen at -20°C to Norway until analysis at the accredited Laboratory of Environmental Toxicology, Norwegian University of Life Sciences (NS-EN ISO/IEC 17025, TEST 137). A liquid/liquid fat extraction and clean-up of the milk samples and gravimetrical lipid determination was done prior to GC analyses. Determination of Organochlorine Compounds (OCs): HCB, HCHs, chlordanes, DDTs, mirex; PCB congeners, IUPAC nos.:CB-28, -52, -101, -118, -138, -153 and -180 and brominated flame retardants (BFRs) PBDE congeners: BDE-47, -99, -100, -153, -154 and -209, and HBCDD were performed with HRGC-ECD, and HRGC-MS according to methods described earlier[9].

Results and discussion

Demographics

The median ages of the primi- and multipara women were 27.0 and 29.5 years, respectively. The age of Saharawi women at first child birth was in the same ranges of European countries, but was higher than in countries south of Sahara. Body mass indexes (BMIs) for all women were ranging from 19 to 37 kg/m^2 with a median of 26 kg/m^2. Most of the women had an education of 7 to 9th grade. Only one had higher education. The majority of the women was born in the refugee camps and lived there all their lives. Median lipid percentages in the breast milk were 4% and 2.7% for primi- and multipara thus 1.3% lower in milk of the multipara. The lipid percentage in breast milk differs strongly between the start and end of the breastfeeding and unawareness of this fact might have caused the difference between the primi- and multiparas.

Tabel 1. Lipid percentages, median, minimum and maximum concentrations (ng/g lipid weight) of HCB, ΣHCHs, ΣDDTs, Σchlordanes, ΣPCBs, ΣBDEs and HBCDD in human milk and milk from goats and camels from Saharawi refugee camps, Tindouf, South-West Algeria.

	Human (N=31)				Goat (N=4)				Camel (N=15)		
	median	min	max		median	min	max		median	min	max
Lipid percentage	3.9	1.0	9.6		4.6	3.3	7.6		3.0	1.1	4.5
HCB	8.3	4.2	15.0		3.1	2.3	3.8		3.3	1.9	5.8
ΣHCHs	32	12	90		2.2	1.2	3.3		2.3	0.82	87
ΣDDTs	55	12	322		4.1	3.7	5.7		0.20	0.05	2.8
ΣChlordanes	2.8	1.1	5.1		0.39	0.05	2.4		<LOD	<LOD	0.49
ΣPCBs	49	19	177		1.6	1.0	31		<LOD	<LOD	11
ΣPBDEs	1.2	0.29	13		1.3	1.0	4.1		<LOD	<LOD	11
HBCDD	1.3	0.24	11		<LOD	<LOD	0.96		<LOD	<LOD	<LOD

Human breast milk

DDT, PCB and HCHs were the dominating OCs in human breast milk (Table 1, Figure 2).and the ΣOC concentrations were 13 and 25 times higher than in goat and camel milk, respectively. A 100% detection level was found for HCB, β-HCH, p,p'-DDE, oxychlordane, PCB-138, -153 and -180. Several OCs were highest in primipara, but the differences were not significant. BDEs were detected in <100% of the human milk samples. Median levels of ΣBDEs were similar for primi- and multipara, whereas levels of HBCDD were highest in the primipara (Table 1). p,p'-DDE contributed 98% to ΣDDTs in both parity groups. This and the fact that the ratio DDT/DDE was 0.03 suggest strongly that the exposure to DDTs is from historic use. This also illustrates that the imported food is from countries with low and historic levels of DDTs. For PCBs the most abundant congeners in human milk were PCB-153, -180, -138 and 118, contributing 41%, 31%, 23% and 4% to the ΣPCBs. Except for ΣHCHs levels, which were five and three times higher than in Germany and Norway, the OC and BFR levels in the Saharawi women were lowest compared to corresponding levels in recent studies performed in Tunisia, Ethiopia, Ghana, India, Germany and Norway (Table 2). This suggests that food items sent to the refugees camps contain very low levels of POPs, which is a positive finding of this study.

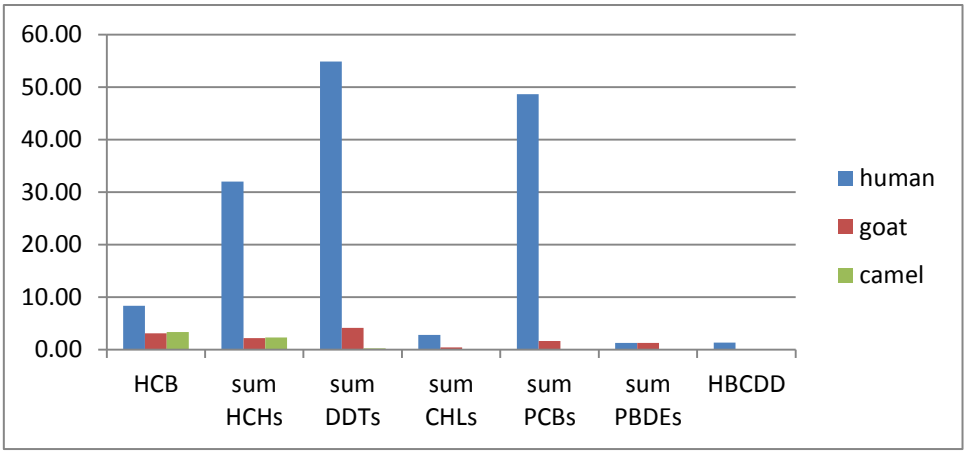

Figure 2. Median concentrations (ng/g lipid weight) of POPs in human milk and milk from goat and camel from Saharawi refugee camps, Tindouf, South-West Algeria.

Goat and camel milk

Median levels of ΣOCs were 17.2 and 8.7 ng/g lipid weight (lw) in goat and camel milk, respectively. HCB levels were similar in goat and camel milk (Tabel 1). The main OCs in the goat milk were DDTs, HCHs and HCB (Table 1), but high PCB levels were found in one of the goat samples. BDE-47, -99 and -153 were detected in 100% of the goat milk samples. Mean ΣDDT levels in goat milk from Ethiopia were 329 ng/g lw[10] and thus 75 times higher than in the Saharawi goats. The OC pattern in camels was dominated by HCB and HCHs andβ-HCH contributed 82% to ΣHCHs. BDEs were only detected in few of the camel milk samples. Although γ-HCH (lindane) was found in low levels in goats and camels, the median level in camel was 6 times higher than in the goat milk (not shown). As mentioned, the goat and camel milk contained comparable levels of HCB whereas the mean levels of ΣHCHs, ΣCHLs, ΣDDTs and ΣPCBs were from one to 9 times higher in goat than camel milk. This diversion indicates different exposure from feed for goat and camel. The fact that goat are fed with soaked cardboard may expose the goat for higher levels of PCB and possibly also for dioxins. Of economic reasons, dioxins were not measured in this study. PCB-118 was only detected in one of the four goats, in levels 1.6 and 2.8 times higher than PCB-153 and -138, which is an unusual pattern. It would be interesting to analyze dioxins and dioxin-like (DL) PCBs in a larger number of goats from this area in order to reveal possible exposure route via cardboard. On a global basis there are only a few studies on POPs in goat and camel. Many of these studies include a limited collection of POPs and are mainly focused on EU Maximum Residue Levels (MRL), whereas only one study was found on toxic equivalents (TEQ) of dioxins and DL PCBs in camel milk[11]. None of the detected OC in goat and camel milk levels exceeded the MRLs.

Table 2. Comparison of median levels of several POPs (ng/g lipid) in human milk, between Saharawi women from Tindouf, Algeria, and other countries.(P: primipara; M: multipara).

Country/region	*N*	Parity	Year	HCB	ΣHCHs	ΣCHLs	ΣDDTs	dde/ddt	ΣPCBs	ΣPBDEs	HBCDD	References
Algeria, Tindouf	31	p+m	2011	8	32	3	55	0.03	49	1.2	1.3	*Present study*
Tunisia	36	p+m	2010	203	63		806	0.73	215	9.8		Hassine et al., 2012
Ethiopia	101		2010				12683	2				Gebremichael et al., 2013
Ghana	42		2009						62	4.5		Asante et al., 2011
Ghana	109			4.9	46		78					Ntow et al., 2008
India	53	p+m	2011-2012		644		2201	0.76				Bedi et al., 2013
Germany	516		2007-2008	16	6		70	0.03	150			Raab et al., 2013
Norway	29	p	2000-2002	18	14	14	110	0.08	172	3.8		Polder et al., 2008

Conclusion

Levels of OCs and BFRs were low in human breast milk from the refugee Saharawi women, and were lower than corresponding levels from other parts of the world. This indicates that the women are exposed to very low POP levels via the food stuffs imported to the camps by UN and international NGOs. DDT levels in goat and camel milk were very low and none of the OCs exceeded EU MRLs. Further studies are needed to reveal the influence of consumption of goat and camel milk on levels and patterns of POPs in the Saharawi women. Sample numbers should be increased, especially for goat milk. The finding of a special PCB pattern in one of the goat milk samples was interesting. Even though PCB levels in the human breast milk were low, it is recommended to include analyses of dioxins and DL-PCBs in future studies.

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